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PNEUMATIC ETCHING DEVICES

The present invention relates to improvements in pneumatic etching devices. In particular it relates to improvements in a device for etching or engraving glass, ceramic or other materials by impact from a flow of abrasive particles.

Pneumatic etching devices are described, for example, in US 4,048,918. This device comprises a gun unit with a tubular barrel, the barrel connected to a reservoir of abrasive particles via a pipe extending from the barrel. The barrel is also connected to a source of compressed air which flows through the barrel. The reduced pressure in the barrel caused by the flow of compressed air causes the abrasive particles to be drawn up the pipe into the barrel where they are entrained in the air flow and propelled onto a surface to be marked, preferably through a stencil.

The barrel is located within a housing with an opening at one end to allow the abrasive material to contact the surface to be marked and a separate filtered outlet for the compressed air. In use, the opening of the housing is held against the surface to be marked and the abrasive particles are propelled against it. Particles rebounding from the surface are contained by the shroud and fall back to the reservoir.

One problem with this arrangement is that the abrasive material and the material removed from the surface being etched can clog in the housing, preventing the device from working efficiently. Another problem is that the seal between the housing and the surface to be marked is generally poor, mainly because the pressure inside the housing is higher than atmospheric pressure. This allows particles to escape from the housing and can also leads to movement of the device over the surface being etched, causing smudging around the edges of the area being etched or, when a stencil is used, blurring of the shape it defines.

These problems are addressed by removing spent material using a vacuum. For example, in GB 2 124 944, the housing also has a coupling which is connected to a

vacuum source.. In use, the spent abrasive particles are contained by the housing and drawn away from the device by the vacuum. A similar solution is described in GB 2 207 625 A.

However, these device need to be connected to both a source of compressed air to drive the abrasive particles and to a vacuum source to draw away the spent particles and eroded material. This makes them unwieldy to use and also necessitates support from two additional machines, usually a compressor and a vacuum cleaner.

The present invention seeks to address this problem by providing a pneumatic etching device which uses a vacuum to remove spent particles from the housing but generates the vacuum internally using the compressed gas source that drives the abrasive particles.

Accordingly, the present invention provides a pneumatic etching apparatus including: entraining means for entraining abrasive particles in a first part of a gas flow and propelling them against a surface to be etched; and drawing means for drawing spent particles and debris away from the surface, wherein the drawing means is powered by a second part of the gas flow.

Preferably, the apparatus includes a shroud for containing the abrasive particles. Preferably, the means for drawing spent particles away from the surface includes a nozzle directing the second part of the gas flow away from the surface, thereby causing a reduced pressure within the shroud. Preferably, the second part of the gas flow is directed to an exhaust port via a convergent chamber communicating with the volume defined by the shroud. Preferably, the apparatus includes means for allowing atmospheric air to enter the shroud close to the surface.

The entraining means preferably includes: a mixing chamber into which the gas flow draws the abrasive particles; and a convergent-divergent blasting nozzle. Preferably, the blasting nozzle and the side walls of the mixing chamber form a single replaceable

unit. Preferably, the abrasive particles enter the mixing chamber via a path in a plane substantially perpendicular to the axis of the convergent divergent nozzle and preferably the path is formed from a channel on the outside of the mixing chamber wall.

The etching apparatus may include a hopper for storing abrasive particles, the hopper including a particle outlet for providing abrasive particles to the entrainment means and a particle inlet for receiving spent abrasive particles. Preferably, the particle outlet is supplied with particles via a valve biased by a spring and a gas flow in the particle inlet.

The above and other aspects of the present invention will now be described with reference to the accompanying drawings in which:
Figure 1 is a transparent view from the side of an embodiment of an etching device according to the present invention;
Figure 2 is a horizontal cross sectional view of the etching device of Figure 1;
Figure 3 is a cross sectional view of a blasting nozzle capsule for use in the etching device shown in Figure 1;
Figure 4 is vertical cross-sectional view of a hopper, which may be used with or incorporated into an etching device according to the present invention;
Figure 5a is a transparent view from the top of a manifold of the hopper of Figure 4;
Figure 5b is a transparent view from the left side of the manifold of Figure 5a; and
Figure 5c is a transparent view from the front of the manifold of Figure 5a.

With reference to Figures 1 and 2, one embodiment of the etching device comprises a substantially cylindrical body 10 with its front end coupled to a substantially cylindrical shroud 11, preferably by a screw thread. The front end of the shroud 11 is connectable to a stencil holder 24 or other shroud attachment. At the back end of the body 10, there is a gas port 12 for operative connection to a supply of compressed gas (not shown) and a particle port 13 for operative connection to a supply of abrasive particles (not shown). Also at this end of the body 10 is a central exhaust port 14

which allows spent abrasive particles, compressed gas and other material to leave the device. The exhaust port has a larger diameter than the gas port and the particle port and in the embodiment shown has a plurality of circumferential flanges 29 for retaining a flexible exhaust tube (not shown).

A gas control manifold 26 is mounted inside the body 10. The manifold 26 houses a blasting nozzle unit 15 and a vacuum nozzle 16, both positioned along the axis of the body 10. The blasting nozzle unit 15 points along the axis of the body 10 towards the stencil holder 24 and the vacuum nozzle 16 is oppositely directed. The manifold 26 also houses a vacuum nozzle supply valve 18 for controlling the gas supply to the vacuum nozzle 16 and a blasting nozzle supply valve 19 for controlling the gas supply to the blasting nozzle unit 15. In the embodiment shown, the valves 18, 19 are piston type valves, biased in the closed position and controlled by actuators 20, 21 which pass through the body 10 of the device. A bore 17 within the manifold and connected to the gas port 12 passes to the vacuum nozzle supply valve 18 and to the blasting nozzle supply valve 19. In the embodiment shown, the valves 18, 19 are in series so that gas cannot be supplied to the blasting nozzle unit 15 unless both the vacuum nozzle supply valve 18 and the blasting nozzle supply valve 19 are open. For convenience, the valves 18, 19 are positioned adjacent to each other so that the actuators 20, 21 are in a line parallel to the axis of the body 10.

An actuating lever 22 is pivoted at one end about a hinge 23 positioned nearer to the back of the body 10 than the actuators 20, 21 of the two valves 18, 19. The lever 22 is positioned so that as the free end of the lever 22 is pushed towards the body 10, the vacuum nozzle supply valve 18 is opened, allowing compressed gas to flow through the vacuum nozzle 16. As the free end of the lever is pressed further towards the body 10, the blasting nozzle supply valve 19 is opened, allowing compressed gas to flow through the blasting nozzle unit 15.

The vacuum nozzle 16 is directed into a frusto-conical chamber 25 which tapers to the exhaust port 14. The frusto-conical chamber 25 is coaxial with the body 10. The

length and diameter of the vacuum nozzle 16 and the shape and size of the frusto-conical chamber 25 are selected to optimise the draw provided by the vacuum system.

Referring to Figure 3, the blasting nozzle unit 15 comprises a cylindrical body 38 with a convergent-divergent blasting nozzle 36 attached at one end. The cylindrical body 38 is adapted for insertion into the gas control manifold 26. An external screw thread 37 positioned approximately half way along the blasting nozzle unit 15 corresponds with an internal screw thread in the gas control manifold 26. The curved wall of the body 38 of the blasting nozzle unit 15 has an annular channel 34 around its external circumference. Within the annular channel 34 is a radial bore 32 through the curved wall of the body 38. In the embodiment shown, the body unit 38 has circumferential O-rings in separate parallel channels on both sides of the annular channel 34.

A gas nozzle 35 fits into the body 38 of the blasting nozzle 15 to form a substantially cylindrical mixing chamber 30 inside the body 38. The gas nozzle 35 is machined to fit tightly and is shown further sealed using an O-ring. The length of the gas nozzle 35 is preferably such that it extends to approximately level with the annular channel 34 in the curved wall of the body 38 of the blasting nozzle 15 when fully inserted.

The gas control manifold 26 has a bore 39 adapted to receive the blasting nozzle unit 15. The diameter of the bore 39 is substantially the same as the external diameter of the body 38 of the blasting nozzle unit 15. The depth of the bore 39 is such that the gas nozzle 35 is held in the blasting nozzle unit 15 by the end of the bore 39 when the blasting nozzle unit 15 is fully inserted into the gas control manifold 26.

The annular channels 34 around the blasting nozzle 15 and the internal wall of the bore 39 in the gas control manifold 26 form a tube around the blasting nozzle unit 15.

A further bore 27 in the gas control manifold 26 leads from the particle port 13 to the tube around the blasting nozzle 15 formed by the annular channel 34.

In use, the blasting nozzle unit 15 tends to wear quickly and it therefore designed to be easily replaceable. The bore 39 for receiving the blasting nozzle unit 15 is easily accessible when the shroud 11 is separated from the body 10 of the device. A worn blasting nozzle unit 15 is easily unscrewed and a replacement screwed in. There is no need to further dismantle the device. In prior art etching devices, the mixing chamber 30 or the blasting nozzle 15 is usually integral to the device as a whole and replacement is more difficult.

To use the etching device, the stencil holder 24 or other shroud attachment is pressed against the material to be etched. The actuating lever 22 is pressed towards the device body 10 to open the vacuum nozzle supply valve 18 and allow compressed gas to flow through the vacuum nozzle. The flow of gas from the nozzle into the frusto-conical chamber 25 causes the pressure in the device body 10 to reduce. This causes the device to suck itself onto the surface to be etched, thereby sealing the stencil holder 24 to the surface.

The actuating lever 22 is then pressed further towards the device body 10 to open the blasting nozzle supply valve 19 thereby allowing compressed gas to flow through the blasting nozzle unit 15. As the gas leaves the gas nozzle 35, it sucks abrasive particles into the mixing chamber 30 by a venturi effect. The mixture of gas and abrasive particles is accelerated by the convergent-divergent nozzle 36 and propelled against the surface to be etched.

Particles rebounding from the surface are entrained in the gas flowing back past the gas control manifold 26 and carried out of the exhaust nozzle 14. The abrasive particles are blown by the gas flow from the blasting nozzle unit 15 and sucked by the reduced pressure created by the gas-flow from the vacuum nozzle 16.

When the surface to be etched has been sufficiently etched, the lever 22 is released, first cutting off the gas supply to the blasting nozzle 15, thereby preventing the release of further abrasive particles. However, the flow of gas from the vacuum nozzle 16

continues to suck the remaining abrasive particles away from the surface that has been etched and blow them towards the exhaust nozzle 14. As the lever 22 moves further from the body 10 of the device, the gas supply to the vacuum nozzle 16 is cut off and the device can be removed from the surface that has been etched.

The abrasive particles enter the device via coupling 13, flow down the bore 27 in the gas control manifold 26, along the annular channel 34 around the blasting nozzle 15 and through the bore 32 into the mixing chamber 30.

It should be noted that in conventional pneumatic etching devices, abrasive particles may continue to flow by a siphoning effect, by gravity or for some other reason. Particularly when etching a horizontal surface, this can leave an abrasive residue on the engraved surface allowing undesired scratching. The present arrangement whereby the abrasive particles flow along the annular channel 34 around the blasting nozzle 15, rather than entering the mixing chamber directly from the bore 27 in the gas control manifold 26 reduces this unwanted dribble effect. Furthermore, maintaining a flow of air from the vacuum nozzle 16 for a short time after the flow through the blasting nozzle has stopped helps prevent scratching of the surface to be etched by rogue particles.

In a preferred embodiment, the shroud 11 has a plurality of small holes drilled around its circumference just behind the connector for the stencil-holder 24 or other shroud attachment. These allow small amounts of atmospheric air to be drawn into the shroud 11, thereby improving the efficiency of the vacuum at removing the abrasive particles.

For etching small areas, the device is used with a stencil holder 24. The stencil holder can have any external shape such as circular, hexagonal, pentagonal, rectangular or square. However, a square shape is preferred since it facilitates alignment of the device with an edge or corner of the surface to be etched. The stencil holder 24 has a machined ledge for retaining most common types of stencil, which are conventionally

disc shaped. The stencil holder is made from metal or plastic in order to withstand the abrasion to which it is subjected.

The device may also be used to etch an area larger than that defined by the shroud 11. This is achieved by replacing the stencil holder 24 with a shroud attachment comprising an annular brush, the bristles being positioned around the circumference of the attachment. A large strip stencil is fixed to the surface to be etched using masking tape and the shroud attachment allows an operator to move the device over the stencil to produce the required design on the surface. Atmospheric air is drawn into the shroud 11 between the bristles of the annular brush, helping to ensure that the abrasive particles are properly contained and improving the efficiency of the vacuum at removing the abrasive particles.

Preferably, the stencil holder 24 or the shroud attachment is attached to the shroud 11 by a frictional fit with an O-ring seal, although a screw thread or other fitting may be used.

In a preferred embodiment the gas used to power the device is compressed air, which is cheap, effective and readily available. However, other gasses may be used if the circumstances require it.

The device is particularly adapted to the etching of artwork, security codes or standard marks on panes of glass but it will quickly be apparent that it may be used in other situations, such as stripping paint, where the etching away of a surface is required.

One skilled in the art will quickly conceive of alternative uses for an etching device incorporating the features of the device described above. For example, on a larger scale, a device according to the present invention can be used for sandblasting buildings, bridges or ships to remove paint of rust. A larger device could be attached to a suitable vehicle and used for removing unwanted road markings.

Some embodiment of the present invention incorporate a hopper as a reservoir for the abrasive particles and as a unit into which spent particles may be directed for recycling.

One type of hopper comprises a sealed pot containing the abrasive particles. Compressed gas is supplied to the sealed pot to force the particles to the etching device. However, the high pressure in the hopper is not advantageous.

Another type of hopper uses an aspirator tube through which the etching device draws the particles from the hopper. However, this type of hopper has been found to provide the particles in small bursts rather than as a smooth flow which makes it difficult to judge when an etch is complete.

Alternatively, particles may be drawn from a hopper by a flow of compressed gas past an outlet from the hopper. This type of entrainment is least appropriate for the etching device described above since it entrains the particles in a gas flow at too early a stage and requires an additional valve to ensure that the flow of particles is stopped when the device is de-activated.

One embodiment of a preferred hopper is shown in Figure 4. The hopper comprises a particle container 50, substantially in the form of a cylinder attached to an inverted cone. The apex of the cone is attached to a domed base plate 51 to allow the hopper to stand upright. The particle container 50 has a removable lid assembly 61 that is held in place on top of the container by snap on clips. The junction between the lid assembly 61 and the container 50 is sealed by a circular rubber gasket 52.

The lid assembly 61 comprises a lid 53 with a large circular central aperture 54. A cylindrical cartridge filter 55 sits on the lid 53 such that the bore through its centre is aligned with the aperture 54 in the lid 53. The top of the cartridge filter 55 is sealed by a circular cap 56. The aperture 54 in the lid is covered from below by the open base of a substantially conical cap 57. The conical cap 57 tapers downwards away

from the lid 53 and has a plurality of small perforations over its surface. The apex of the conical cap 57 sits against the outer surface of a substantially hemispherical deflector 58, approximately at the centre of the deflector 58.

The entire lid assembly is held together by a bolt 59 which passes through the centre of the circular cap 56, the bore in the cartridge filter 55, the aperture in the lid 54, the apex of the conical cap 57 and the centre of the deflector 58. The bolt is secured with a nut 60.

At the bottom of the hopper, within the domed base 51 is a hopper manifold 62. The particle container 50, base 51 and manifold 62 are held together by bolts passing from inside the particle container 50 to threaded bores 63 in the hopper manifold 62.

Referring to Figure 5, the manifold 62 has an abrasive particle outlet 64 for supplying abrasive particles to the particle port 13 of the etching device. Particles enter the manifold 62 via a supply bore 65 connecting the particle container 50 with a valve chamber 66. The diameter of the supply bore 65 is important ensuring a consistent supply of an appropriate amount of particles and is dependent on the size of abrasive particles used. In the embodiment shown, the valve chamber 66 has an outlet leading to a spring chamber 67 with a larger diameter. The spring chamber 67 contains a ball bearing 68 with a diameter larger than the diameter of the valve chamber 66 and a spring 69 which biases the ball bearing 68 against the outlet from the valve chamber 66. The outlet of the valve chamber 66 and the ball bearing 68 thus form a valve which is biased into a closed position by the spring 69. The spring chamber 67 connects to the particle outlet 64. In an alternative embodiment (not shown), the particle valve formed by the ball bearing 68 and spring 69 may be omitted.

In a preferred embodiment (shown), there are three small supply bores 65 of 1.5mm diameter and the abrasive particles are a 220 grade grit. It was found that a single larger hole did not allow the abrasive particles to flow as smoothly into the valve chamber 67 and it was occasionally necessary to shake the hopper to make the

particles flow. The three supply bores 65 ensure that the valve chamber 67 does not completely fill with grit, thereby facilitating operation of the valve.

The manifold also has a larger abrasive particle inlet 70 for receiving particles, gas and other material from the exhaust port 14 of the etching device. The particles are delivered into the particle container 50 via a vertical delivery tube 71 which passes through the apex of the particle container 50 and terminates below the internal surface of the deflector 58. In the preferred embodiment shown, there is a small connecting biasing bore 72 between the valve chamber 67 and the delivery tube 71. The biasing bore preferably enters near the top of the valve chamber 67 so that it is not blocked by abrasive particles in the valve chamber 67.

In one embodiment, the manifold 62 has a first coupling 73 for the supply of compressed gas and a second coupling 74 for attachment of a hose connecting the gas supply to the gas port 12 of the device. This enables all connections to the device to be bundled together between the hopper and the device facilitating use by avoiding untidy connections.

The hopper is preferably made from metal or another conductive material which can be earthed to prevent the build up of static charge.

Abrasive particles are stored in the hopper to a depth below the top of the delivery tube 71.

As the etching device is actuated, compressed gas passes through the vacuum nozzle 16. This gas flows through the exhaust port 16 of the device and the abrasive particle inlet 70 of the manifold and up the delivery tube 71. The gas circulates around the deflector 58 and out through the cartridge filter 55. The pressure in the delivery tube 71 is transmitted through the biasing bore 72 to reduce the bias generated by the spring 69 on the particle valve. The residual pressure in the particle container 50 helps to push the particles through the supply bores 65.

When the device is fully actuated and gas passes through the blasting nozzle 15, the draw created opens the particle valve (if present), allowing particles to be sucked along the connecting hose to the device. The spent particles will be carried by the established gas flow through the abrasive particle inlet 70 of the manifold and up the delivery tube 71. The abrasive particles will hit the deflector 58 and be pushed down into the particle container 50 for re-use. Since by this stage, the particles are travelling at relatively low speeds, wear to the deflector is not excessive. Further separation of the gas from the particles is achieved by the conical cap 57 and the cartridge filter 55. The particles fall back into the particle container 50 and the gas is vented to atmosphere.

When etching is complete, the device is de-activated. First the gas flow through the blasting nozzle 15 is stopped. The reduced draw from the device causes the particle valve in the hopper to close (if present), preventing particles leaving the hopper. The gas flow through the vacuum nozzle 16 clears the particles from inside the shroud 11 and carries them back to the hopper.

Finally, the gas flow through the vacuum nozzle 16 is stopped. This reduces the pressure in the delivery tube 71, further sealing the particle valve and preventing particles from leaking towards the device, particularly as a result of the siphoning effect mentioned above.

The particle valve arrangement is particularly useful as a safety feature. The draw from the blasting nozzle 15 of the device is not sufficient to overcome the bias created by the spring 69 and allow particles to flow to the etching device. It is also necessary to connect properly the exhaust port 14 of the device to the particle inlet 70 of the manifold in order to reduce the bias created by the spring 69 on the particle valve. Therefore, it is not possible for particles supplied from the hopper described above to be blown directly to atmosphere from the exhaust port 14 of the device.

Many variations are possible. For example, the shape of the particle container might be varied or a different filtering system might be used.

One skilled in the art will readily conceive of alternative embodiments of the invention described above. The present invention includes all such alternatives which fall within the scope of the following claims.